MACHAKOS UNIVERSITY

University Examinations 2019/2020Academic year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FIRST YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE IN APPLIED PHYSICS AND TECHNOLOGY

SPH 106: MECHANICS

DATE: 10/12/2019 **TIME: 2.00-4.00 PM**

INSTRUCTIONS TO CANDIDATES

Answer **QUESTION ONE** and **ANY OTHER TWO** questions.

Question 1 carries **30**marks and the others carry **20**marks each.

YOU MAY USE:

You may need to use the following constants

- Density of water= 1.0 x 10^3kg/m^3
- Acceleration due to gravity, g=9.8 m/s^2
- Universal gravitational constant G=6.67 x10^{-11}N$m^2$$kg^{-2}$
- Mean radius of the earth R_e=6400 km
- Mass of the Earth, m_e, = 5.972 x 10^{24} kg
- Permittivity of free-space, $\varepsilon_o = 8.85 \times 10^{-12}$ F/m

QUESTION ONE (30 MARKS)

a) Use dimensional analysis to derive the dimensions of the following quantities;

i. Time (1 mark)

ii. Energy (2 marks)

iii. Acceleration (1 mark)

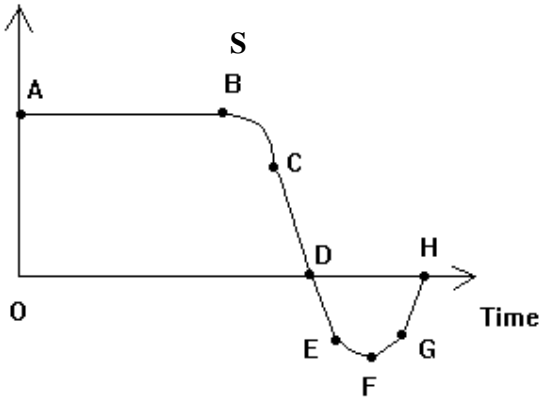
b) Differentiate between adhesive and cohesive properties of matter (2 marks)

c) i Distinguish between vector and scalar quantities giving an example of each. (3 marks)

ii Find the angle between the vectors **A** = 2**i**+**k** and **B** = 3**i**+4**j**+5**k** (4 marks)

d) While writing its mathematical expression, state the universal law of gravitation (3 marks)

e) Describe the motion of a body that is represented by the following displacement-time graph for sections: **OA, AB, BD, CD, EF** and **OH** (6 marks)



f) A spring has a spring constant of 40 N/m. If it is stretched by 0.3 cm from its equilibrium, how much work is done? (3 marks)

g) Write Poiseulle's equation and state one application (3 marks)

h) Differentiate between laminar and unsteady flows (2 marks)

QUESTION TWO (20 MARKS)

a) Show that at a height, h above the earth's surface, the acceleration due to gravity g_h is related to the acceleration due to gravity at the earth's surface, g by the equation,

$$g_h = \frac{g}{\left(1+\frac{h}{R_e}\right)^2}$$

where R_e is the radius of the earth (8 marks)

b) What is the value of acceleration due to gravity at an altitude of 500 km? Radius of the earth is 6400km (3 marks)

c) i Show that the horizontal range (R) of a projectile is given by,

$$R = \frac{u_0^2 \sin 2\theta}{g},$$

Where all the symbol have their usual meaning. (3 marks)

ii If the angle of projection is $45°$ and the range is 110m, calculate the initial speed and the time of flight of the projectile. (3 marks)

d) Show that bodies projected at 30^0 and 60^0 have the same range. (3 marks)

QUESTION THREE (20 MARKS)

a) In cartesian co-ordinate system, show that

i. $i \cdot i = j \cdot j = k \cdot k = 1$ (2 marks)

ii. $i \cdot i = j \cdot k = k \cdot k = 0$ (2 marks)

iii. $i \times i = j \times j = k \times k = 0$ (2 marks)

iv. $i \times j = k$, $j \times k = i$, $k \times i = j$ (2 marks)

b) A 2000 kg vehicle with a speed of 25 m/s strikes another moving car with a speed of 16m/s whose is 1200kg.

i. What is the velocity of the junk? (4 marks)

ii. Find the fractional part of the kinetic energy that the cars have after collisions. (4 marks)

iii. What is the total momentum after collision? (4 marks)

QUESTION FOUR (20 MARKS)

a) State the three Kepler's laws of gravity (4 marks)

b) What is escape velocity? Determine the escape velocity for a body from the earth's surface. (4 marks)

c) A wire of a length 1m and diameter of 0.4mm is hung from a ceiling. Find the extension caused in the wire, by attaching a weight of 100N, if the material of the wire has the Young's modulus of $200 \times 10^{11} Nm^{-2}$. (4 marks)

d) Discuss any 2 factors affecting the surface tension in a liquid. (4 marks)

e) Determine the curl and div. of r, where $\boldsymbol{r} = 2xy^2\boldsymbol{i} - 3zx^3\boldsymbol{j} + 5zy\boldsymbol{k}$ (4 marks)

QUESTION FIVE (20 MARKS)

a) Civil engineers generally *bank* curves on roads in such a manner that a car going around the curve at the recommended speed does not have to rely on friction between its tyres and the road surface in order to round the curve. Suppose that the radius of curvature of a given curve is r = 60 m, and that the recommended speed is $v = 60 km/hr$. At what angle θ should the curve be banked? (4 marks)

b) Derive the expression for total energy per unit volume of a fluid flowing in an unequal horizontal pipe (6 marks)

c) A drop of water of radius 0.0015 m is falling in air. If the coefficient of viscosity of air is 1.8 x 10^{-5} Kg/ms, what will be the terminal velocity of the drop? (Density of water is $1000 Kgm^{-3}$, neglect density of air). (4 marks)

d) Prove the consistency of Keppler's third law (6 marks)